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Systematic Review
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Systematic review of the incidence of inferior alveolar nerve injury in bilateral sagittal split osteotomy and the assessment of neurosensory disturbances

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Abstract. Extreme variation in the reported incidence of inferior alveolar nerve (IAN) disturbances suggests that neurosensory disturbances after orthognathic surgery have not been evaluated adequately. Here we review the reported incidence of IAN injury after orthognathic surgery and assess recently reported methods for evaluating sensory disturbances. A search was conducted of the English-language scientific literature published between 1 January 1990 and 31 December 2013 using the Limo KU Leuven search platform. Information on various aspects of assessing IAN injury was extracted from 61 reports. In 16 reports (26%), the incidence of injury was not indicated. Preoperative IAN status was not assessed in 22 reports (36%). The IAN assessor was described in detail in 21 reports (34%), while information on the training of the assessors was mentioned in only two reports (3%). Subjective evaluation was the most common method for assessing neurosensory deficit. We conclude that the observed wide variation in the reported incidence of IAN injury is due to a lack of standardized assessment procedures and reporting. Thus, an international consensus meeting on this subject is needed in order to establish a standard-of-care method.

Key words: incidence; inferior alveolar nerve; bilateral sagittal split osteotomy; neurosensory disturbance.

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The bilateral sagittal split osteotomy (BSSO) is a common procedure for treating mandibular deformity. The benefits of BSSO include better masticatory function,[1–3] reduced temporomandibular joint pain,[4,5] and improved facial aesthetics.[6,7] BSSO is also increasingly indicated in the treatment of obstructive sleep apnoea. The osteotomy in BSSO is performed in close proximity to the inferior alveolar nerve (IAN), and thus IAN damage often results.[8] The incidence of IAN

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deficits after mandibular osteotomies varies from 0% to 100%.[9,10] Deficits include numbness or unusual sensations in the lower lip, chin, teeth, and gingiva. Paresthesia is usually transient, but may be permanent.

IAN damage accounts for the majority of postoperative complications of BSSO.[11–13] IAN injury during surgery largely results from manipulation of the nerve or structures surrounding the nerve, or from direct injury to the nerve during the operation.[14–16] IAN damage can consist of complete or partial transection, extension, compression, crushing, or ischaemia. Damaged nerve fibres can be categorized as neuropraxia, axonotmesis, or neurotmesis depending on the extent of the damage.[17] In clinical settings, various combinations of nerve damage co-exist, which give rise to a variety of sensory dysfunctions.

Damage to the myelin sheath of neurons results in demyelination, which impairs the conduction of signals in affected nerves. In turn, the reduction in conduction ability causes deficiencies in sensation. Varying degrees of demyelination occur in neuropraxia and axonotmesis and lead to a variety of symptoms depending on the damage. The main symptoms of IAN injury are loss of sensory function of the lower lip on the affected side and in the mental region and the gingiva. Persistent pain or neuropathic pain such as allodynia and pain and discomfort with occlusion can occur.[18,13] These complications have a severe effect on quality of daily life and often lead to litigation and patient complaints about their treatment.[19]

There is wide variation in the reporting of the incidence of IAN disturbances after orthognathic surgery. The incidence of nerve damage apparent at operation during BSSO has been reported to vary from 1.3% to 18%,[20] while postoperative sensory disturbances in the lower lip and chin have been reported to occur in 9–85% of operated sides.[21] This extreme variation suggests that neurosensory disturbances after orthognathic surgery are difficult to assess in a standardized fashion that is easily applicable in daily surgical practice. However, in order to assess the impact of IAN injury after orthognathic surgery and to evaluate the needs of affected patients, it is important to determine the true incidence of IAN disturbance after orthognathic surgery.

The aim of the present investigation was to review the reported incidence of IAN injury after orthognathic surgery and to assess the methods used to evaluate IAN sensory disturbances in reports published between 1990 and 2013. Both the frequency of reporting and the type of information provided were examined. In addition, we propose several recommendations that may improve the assessment and reporting of IAN disturbances.

Methods

A search was conducted of the English-language scientific literature published between 1 January 1990 and 31 December 2013 using the Limo KU Leuven search platform, which retrieves data from sources including MEDLINE, Web of Knowledge, OneFile, and online platforms of various publishers. The following search terms were used: incidence, inferior alveolar nerve, sensory disturbance, and mandibular osteotomy. The aim of this survey was not to review all available reports, but rather to focus on the aspects of methods of assessment of the incidence of IAN damage after BSSO in a relevant sample of reports. Reports in the grey literature (information not appearing in the periodic scientific literature obtained from a library, the Internet, or by ordering) were not pursued. The criteria for retention of reports for further processing were the following: reports written in the English language; study carried out in humans; original study (randomized, non-randomized clinical trial, cohort studies, case–control studies, case reports); full text or abstract of the report available for assessment; study related to BSSO as the type of orthognathic surgery; publication date from 1990 to 2013; report assessing IAN sensory disturbances. All reports that met the above criteria were retained for further processing.

An independent duplicate review of titles, abstracts, and full-text versions (where necessary) was performed by two researchers (JOA and ASS). During the selection process, reports for which neither the abstract nor the full text could be obtained were eliminated, as were reports not related to IAN sensory disturbance in humans. Duplicate reports were also excluded.

Instances of disagreement in the study selection process were resolved by discussion between the two researchers. The following information was extracted from the reports: incidence of IAN injury, types of IAN injury, methods of assessing IAN injury, and period of follow-up. Scoring was performed independently by two researchers (JOA and ASS). In the case of disagreement, a final conclusion was reached by consensus.

Results

The initial search identified 150 reports. A first step excluded reports for which neither the abstract nor the full text could be retrieved (46 reports). Based on the abstracts, reports not related to IAN sensory disturbance in humans were eliminated (23 abstracts), leaving 81 abstracts eligible for inclusion. Based on the full-text reports, an additional 20 papers were excluded because they were duplicates. Sixty-one reports remained for final inclusion in the review and encompassed investigations that were carried out between 1994 and 2012. Table 1 summarizes the frequency of reporting of the different items considered.

In 16 reports (26.0%), the incidence of IAN injury was not indicated (Table 1). The preoperative status of the IAN was also not assessed in 22 reports (36.1%; Table 1). Details of the IAN assessor were mentioned in only 21 (34.4%) of the reports included, while information on the training of the assessors was mentioned in only two reports (3.3%). The type of IAN injury was not indicated in approximately half of the reports evaluated (45.9%).

IAN neurosensory disturbance was assessed subjectively in 47 papers (77.0%), while objective methods of assessment were reported in only 14 of the papers evaluated (23.0%) (objective method alone in seven reports (11.5%) and both

Table 1. Frequency of reporting of items considered.

Items	Articles reporting the item		Articles not reporting the item	
	Number	Percentage	Number	Percentage
Preoperative assessment	39	63.9	22	36.1
Incidence	45	73.8	16	26.2
Type of injury (specific)	33	54.1	28	45.9
Method of assessment	61	100.0	0	0.0
Follow-up period	58	95.1	3	4.9
Information about assessor given	21	34.4	40	65.6
Assessor training	2	3.3	59	96.7

Table 2. Sample size for the various methods of assessment.

Sample size	Number of reports			Total number of reports
	Subjective	Objective	Subjective + objective	
10–50	19	5	6	30
51–100	11	1	0	12
>100	17	1	1	19

subjective and objective methods in seven reports (11.5%)).

In 42 reports (68.9%), the number of subjects was less than 100; in only 19 reports (31.1%) did the number of subjects exceed 100 (Table 2). The sample size for reports with objective assessment ranged from 10 to 60 subjects (excluding outliers), with a median value of 20 subjects, while the sample size for reports relying on subjective methods ranged from 7 to 190 subjects, with a median value of 60 subjects. The variability in sample size was greater for studies employing subjective methods, as was the median number of subjects.

Discussion

There is wide variation in the reported incidence of IAN disturbance after orthognathic surgery. These variations have been attributed to several factors, such as variability in nerve function assessments, variation in follow-up periods between studies, and assessor experience. We used a pre-determined checklist to extract information on the method of assessing neurosensory disturbance, the timing of assessment, the number of subjects included in the study, assessor training and validation, and methods of reporting the incidence of IAN disturbance.

Assessment is often categorized as either objective or subjective. An objective test is based on fact rather than on the feeling or opinion of the subject, while a subjective test arises out of, or is identified by means of, the patient's perception of their own states and processes, which are not observable by an examiner.[22,23] Table 3 describes some of the subjective and objective methods used to assess IAN in the set of reports retrieved.

Our observation that most neurosensory measurements are based on subjective feelings of sensation during an objective stimulus procedure explains the wide range of results. Although Westermark et al.[24] reported a relatively good positive correlation between subjective evaluation and objective assessment of the sensitivity of the lower lip and chin after BSSO of the mandible, the human variables introduced by both examiner and patient, the crude method of assessment, and the use of poorly controlled testing stimuli, make it unlikely that different methods would yield the same result for all individuals. Also, there is usually marked biological variability among study subjects.

We observed that the incidence of IAN impairment was higher in reports employing subjective methods than when objective methods were used (Fig. 1). According to Colella et al.,[25] the higher frequency of IAN impairment indicated by subjective methods suggests that subjective reporting may include sensory impairments that do not appear to be confirmed by objective testing. Another explanation is that the subjects perceive altered sensation that in a real sense is not present. Although it has been argued that patient satisfaction does not depend on objective test results but rather on patient perceptions of altered sensation following orthognathic surgery,[26] the low specificity of subjective tests, their lack of reproducibility, and the possibility of false-positive results make subjective tests less accurate for diagnostic use. To increase diagnostic accuracy, objective tests for sensory disturbances are recommended.

Also of importance is the sample size of the studies from which the incidence rate is obtained. The sample size determines the amount of sampling error inherent in a test result. It is expected that large samples yield more reliable results. Small samples cause a lack of confidence in the results due to the inadequate power of a statistical test.[27] Other things being equal, effects are harder to detect in smaller samples. Our observation that both assessment methods

Table 3. All subjective and objective methods used to assess the inferior alveolar nerve in the reports included.

Number	Subjective tests	Objective tests
1	Questionnaire/interview	Electromyography
2	Tactile discrimination	Electronic thermography
3	Two-point discrimination	Mental nerve blink reflex
4	Moving two-point discrimination or Dellon test	Trigeminal somatosensory evoked potential
5	Thermal stimuli	Orthodromic sensory nerve action potential
6	Pain detection threshold	Nerve conduction study
7	Nociception (pin-prick discrimination)	
8	Sharp–blunt test (sharp/blunt discrimination)	
9	Global sensitivity score (light touch sensation and pin-prick sensation)	
10	Tooth vitality assessment via analytical pulp tester	
11	Computer-aided thermal sensitivity testing using pain and thermal test device	
12	Grating orientation discrimination	
13	Light touch	
14	British Medical Research Council scale of neurosensory recovery	
15	Quantitative sensory tests,[a] cold detection test, warm detection test, heat pain threshold	
16	Brushstroke directional discrimination	
17	Current perception threshold[a]	

[a] These methods of assessment are subjective and were used as objective in some reports.

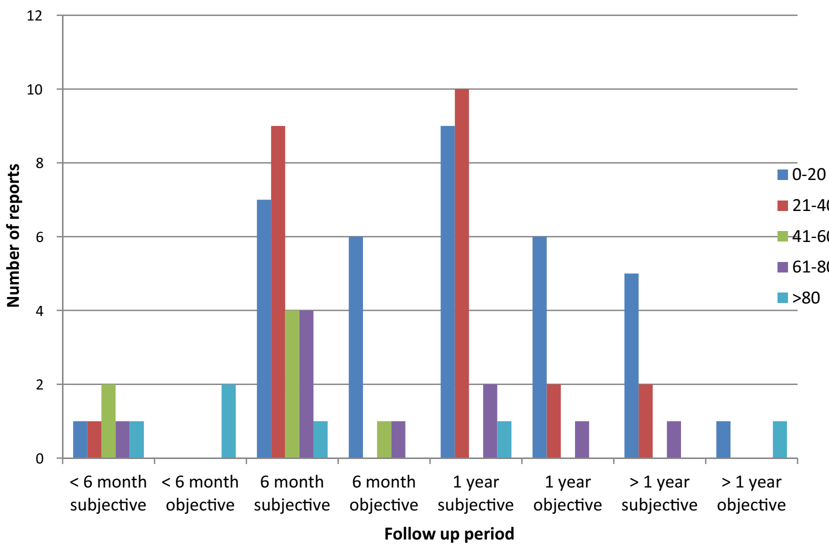

Fig. 1. Incidence of inferior alveolar nerve injury in reports, according to the length of follow-up.

had low median sample sizes (20 for objective and 60 for subjective assessment) shows that the results of the studies included may not be representative of the condition in the population. Increasing the sample size is often the easiest way to boost the statistical power of a test, and therefore larger samples are needed to assess associated morbidities.

Accurate and reliable assessment of a condition by the examiner contributes critically to the overall quality of a study. Therefore, it is important to evaluate the validity of scoring by the examiners. The training of assessors before (and sometimes repeatedly during) a study guarantees the validity of scoring.[28] The outcome of training is assessed in calibration exercises. Intra- and inter-examiner agreement are assessed using data obtained from calibration exercises.[28] These agreement measures (when reported) provide information about the reliability of the data.

Of the 61 reports providing information on the methods with which the examinations were performed, 21 (34.4%) gave information about assessors and two (3.3%) provided information on assessor training and calibration. No report provided information on intra- and inter-observer agreement, although some studies presented data on agreement between subjective methods and objective methods. A lack of assessor training and standardization results in the introduction of human variables and inconsistencies into the data. Intra- and inter-observer inconsistencies for various assessment methods (subjective and objective methods alike) result in wide variability in the reported incidence of IAN neurosensory disturbance after orthognathic surgery. We recommend training and calibrating assessors and using validated standardized protocols in future evaluation studies.

Another matter of concern is terminology. While most papers use terms such as hypoesthesia, reduced sensitivity, and numbness,[21] others use paresthesia as a synonym for identical findings.[29] This uncertainty complicates clinical diagnosis and contributes to the diversity of findings, with scientifically meaningless evaluation categories such as ‘good’, ‘fair’, or ‘poor’ levels of sensory function.

In epidemiology, incidence is defined as a measure of new cases arising in a population over a given period. It is calculated by comparing the number of people found to have the condition with the total number of people studied, and is usually expressed as a fraction, as a percentage, or as the number of cases per 10,000 or 100,000 people. Of the 61 reports assessed here, information on the incidence of IAN injury was explicitly indicated in 45 (73.8%), meaning that over a quarter of reports lacked this valuable information. The reported incidence varied from as low as 1.6% in one study group to as high as 90% in another.

How reported incidences are obtained is also important. Some reports present values for regions of the mouth such as the lower lip, chin, and labiomental area, while others indicate incidences for the right and left sides of the mouth. Some publications reported a single value without indicating the part of the mouth from which the value was obtained. Additionally, we observed variability in how the researchers reported the values of readings from assessment methods. While some reported averages from two or more readings, others reported ranges or maxima. Values were presented as percentages, proportions, relative values, and/or absolute values. Few reports provided *P*-values.

The time-point at which IAN disturbance was assessed also varied. A preoperative assessment was not performed in 22 reports (36.1%), meaning that the true state of the IAN before surgery could not be ascertained in these cases. After the operation, the time-point of IAN assessment also varied; the earliest reported was 4 days after surgery, while in some reports IAN functionality was first assessed 6 months after BSSO. The system of performing all testing at the post-injury stage makes it difficult to have individual baseline results available for comparison and for true determination of the magnitude of damage. The lack of standardization of objective methods and time to the evaluation of sensory dysfunction after BSSO results in a vast range of prevalences of neurosensory disturbance at 1 or 2 years postoperatively, from 0% up to 85%.[14]

The wide variation in the timing of assessment makes it difficult to compare studies with each other. For quality control, preoperative and postoperative measurements and documentation of postoperative recovery of sensation are recommended. Since recovery appears to occur at characteristic intervals, serial examination following surgery is also recommended. Postoperative examination intervals should, at a minimum, include assessments immediately after surgery and at 6 weeks, 3 months, 6 months, and 12 months following surgery.

Differences in the regions of IAN assessment, methods used, and units of reporting render the uniform interpretation and generalization of observations difficult. Researchers should provide detailed and clear descriptions of their methods and employ a standardized unit of reporting. We recommend setting up an international consensus meeting to establish a standard-of-care method to evaluate IAN sensory function. At present, no purely objective clinical neurosensory testing modalities exist for the evaluation of iatrogenic injury to the terminal branches of the trigeminal nerve. All tests require patient cooperation and are based on patient responses, thus introducing a subjective component into the ‘objective’ process.

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Patient consent

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